

FLOATING ENERGY RESEARCH FORUM

28th June 2023

AFFIDA Project – Structural
health for FOWT from O&G
experience to validation on PGL
pilot farm





PRINCIPIA KEY FACT



Independent Engineering Company:

- **Employee:** 125 Engineers / **Offices:** France / Malaysia
- **Local partners:** South Korea and China
- **Sectors :** Oil & Gas / Marine Renewable Energies / Naval
- **Scope of Services – FOWT Projects:**
 - ❖ Offshore Site Screening
 - ❖ Technologies Screening
 - ❖ **Integrated Engineering Package** (floater, mooring, power cable through integrated load simulations)
 - ❖ LCOE Assessment
- **Track Record - FOWT Projects**
 - ❖ **Technology screening** for tenders support : **+20 Projects**
 - ❖ **Engineering packages** delivered for Spar, Semi Sub, TLP, counter weighted spar: **+ 30 projects**

SOFTWARE development and distribution for FOWT systems:

- **DeepLines Wind Software** – Offshore Wind FEA Software
- **DTA m** – Digital Twin for Availability monitoring Software



Hywind Scotland Pilot Park
Provence Grand Large Pilot Park
Eolmed Pilot Park
Dounreay Tri Demonstrator
TetraSpar Demonstrator
SeatWirl S2 Demonstrator
MPS Demonstrator



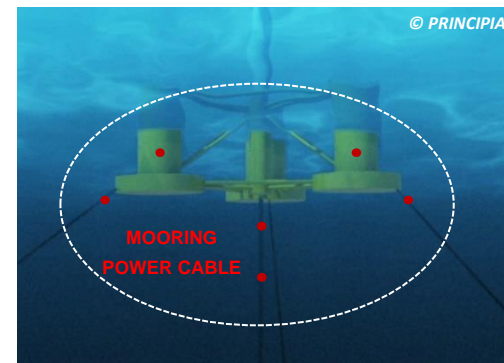


AGENDA

Structural health for FOWT from O&G experience to validation on PGL pilot farm

- Lessons learned from monitoring strategies deployed on Oil & Gas floating units
- Screening of monitoring strategies for Floating Wind Turbines
- Key drivers for FOWT monitoring strategy deployment, focused on floating foundation, mooring and power cables
- State of the art monitoring solution through combined digital twins and data science technologies
- **Case Study:** Real time Structural Health Monitoring (SHM) solution developed on PGL French Floating Wind Pilot Park (EDF RENEWABLES / ENBRIDGE)

Presentation focused on monitoring strategy developed for floating foundation, mooring system, dynamic power cable

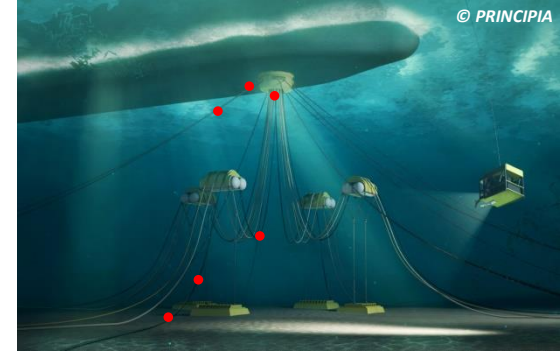




Lessons learned from Oil & Gas

Lessons learned from monitoring strategy deployed on Oil & Gas floating units:

- Mainly based on direct monitoring strategy:
 - ❖ System instrumented at locations of interest
 - ❖ Deployed for subsea application
 - ❖ Requirement for data storage facility
 - ❖ Requirement for re-engineering based on in-situ data
 - ❖ Complexity of installation phase
- This method has raised some concerns:
 - ❖ Are we sure about **sensors locations versus critical area**? Based on design assumptions not yet validated based on in situ data
 - ❖ Are **subsea sensors reliable for 20 years** ?
 - ❖ **How/where to store data** waiting for re-assessment of offshore asset
 - ❖ **Would we have engineering team ready** during operational phase to perform a re-assessment



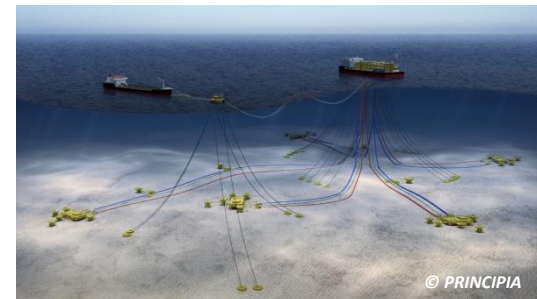
**Additional CAPEX and OPEX costs
&
Finally, most of monitoring
systems remain un-used**



Lessons learned from Oil & Gas

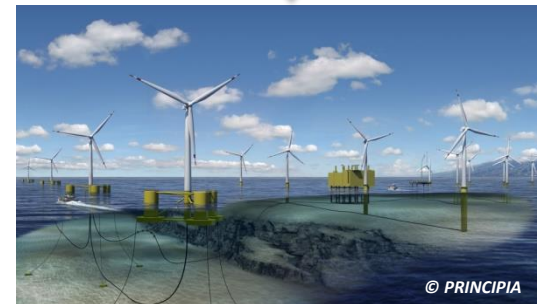
Lessons learned from monitoring strategy deployed on Oil & Gas floating units:

- How monitoring strategy can do better to reduce costs and increase reliability:
 - ❖ Limit number of sensors, mainly deployed above sea level
 - ❖ Limit impacts with procurement / transportation and installation
 - ❖ Avoid man-power commitment for post processing
 - ❖ Automatic post processing without need of large data storage
 - ❖ Realistic model for understating of how to better perform cleaning / filtering of data and then ensure accuracy of results
- Alternatives to direct monitoring strategy
 - ❖ **Monitoring by Simulations**
 - ❖ **Digital twins based Structural Health Monitoring**



Learn from Oil & Gas Monitoring System

Leading to costs optimization for FOWT Projects



The technological platform has been already delivered for the follow-up of risers and mooring lines integrity

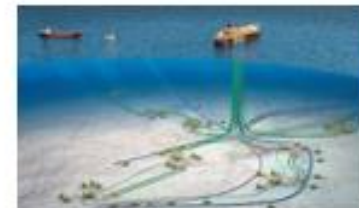


Oil & Gas Project References



Fatigue Life of Steel Catenary Risers

Status : DEMO installed in TOTAL Energies offices and being proposed to TOTAL's projects



Fatigue Life of Chain Mooring Lines

Status : Monitoring tool installed on-board since July 2019



Fatigue Life of Steel Offloading Lines

Status : Jubilee project - Monitoring system installed Offshore in November 2020 (Just commissioned after COVID period)

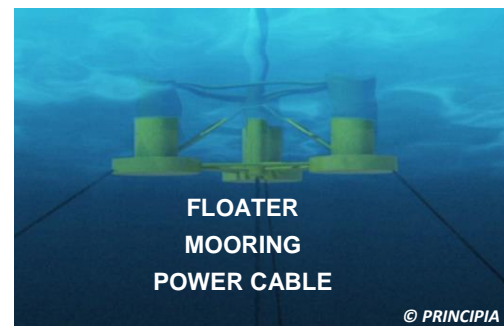
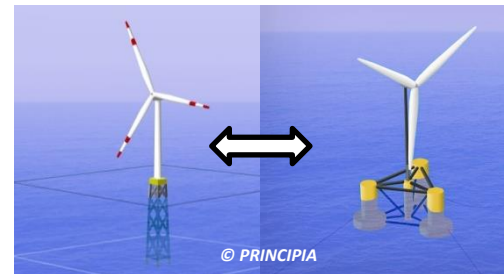




Monitoring Strategy

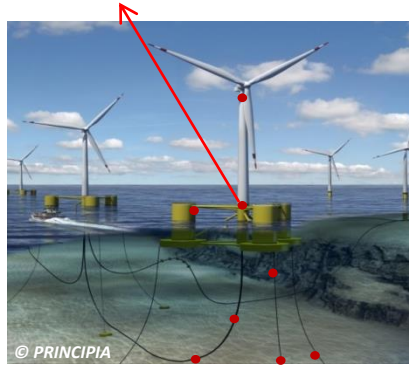
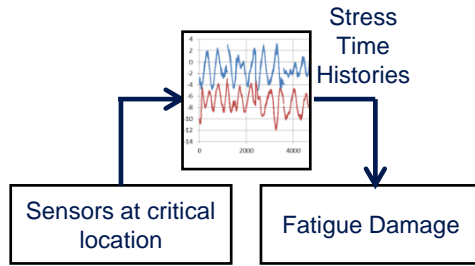
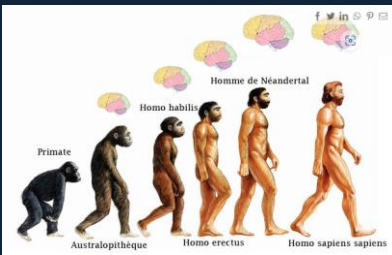
Specificities of Floating Wind monitoring strategy

- Offshore Wind Floating foundations:
 - ❖ More dynamic than bottom-fixed and subject to severe fatigue loading
 - ❖ Monitoring strategy deployed for Oil & Gas units shall be adapted carefully as physics are not the same
- New critical elements from bottom-fixed system :
 - ❖ **Floating Foundations**, design mainly driven by fatigue
 - ❖ **Mooring system**, with oil & gas experience showing potential failures (OPB and others)
 - ❖ **Dynamic cable**, already identified as weak element for Bottom fixed and subject to very dynamic loading for FOWT
- Strong coupling /non linearity between Turbine, Floater and mooring system : bottom fixed monitoring solutions not applicable





Screening of Monitoring Strategy

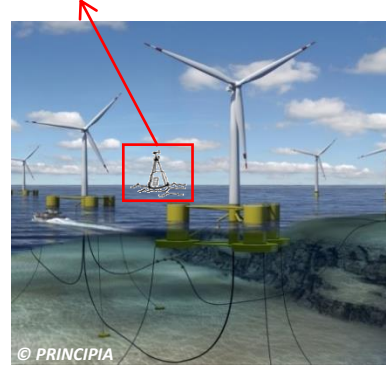
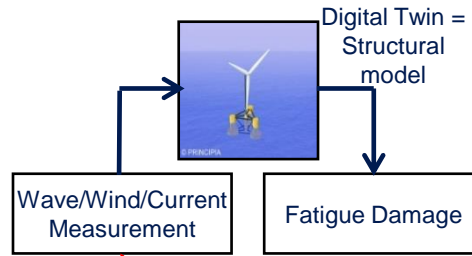


DIRECT MONITORING

Most Intuitive Solution

Reliability Issues of Subsea Sensors

Expensive Monitoring Solution

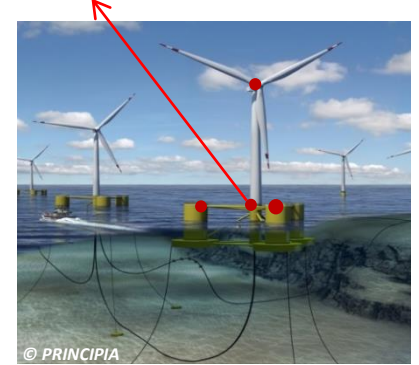
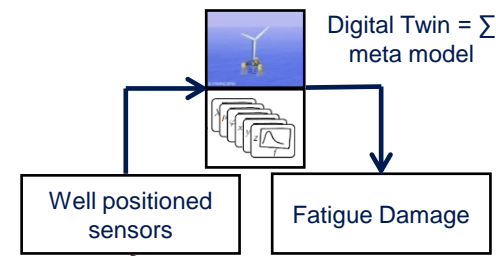


MONITORING by SIMULATIONS

Few Sensors

Expensive Monitoring Solution

Sensitive to Global Model Accuracy



STATE of THE ART MONITORING

Few Sensors / Cost Effective

Real Time Condition Monitoring

Abnormal Events Detection





Key drivers for FOWT monitoring

Steps for effective deployment of State-of-the Art FOWT monitoring Strategy

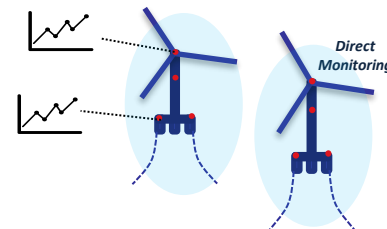
- Deploy direct monitoring strategy on prototype / pilot farms to:
 - ❖ De-risk system behaviour on site under realistic environmental conditions, especially for low TRL concept
 - ❖ Allow fine calibration of the coupled numerical model
 - ❖ Allow validation of SHM system reliability and try combination with autonomous subsea inspection devices to follow long term evolution of system (marine growth, corrosion etc...)
- Deploy SHM for commercial farms as:
 - ❖ Only system allowing accurate monitoring of each unit
 - ❖ Associated to limited CAPEX impact and high reliability

SHM shall allow for fatigue integrity monitoring of:

- Floating foundation
- Mooring system
- Dynamic cable

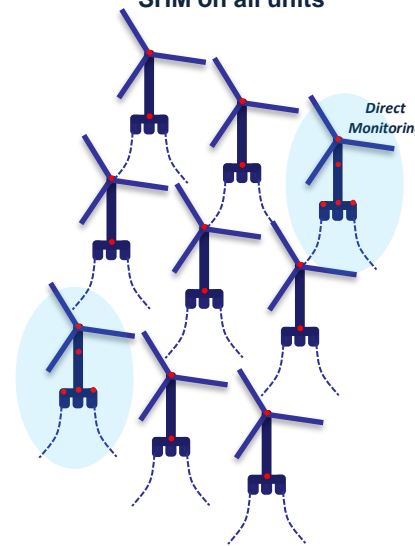
PROTOTYPE / PILOT FARMS

Direct Monitoring
+ Validation of SHM



COMMERCIAL FARMS

Direct Monitoring on few units
SHM on all units



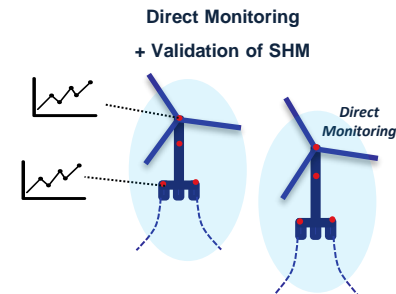


FOWT SHM System

State of The Art Monitoring Strategy for FOWT combining digital twin with data science technology:

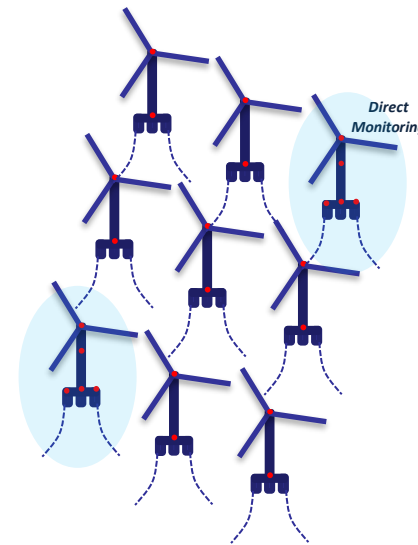
- **Minimum cost investment:**
 - ❖ Limited number of sensors
 - ❖ Limited impact on floating unit deployment / procurement
 - ❖ No need of engineering team when operating
- **Efficient and reliable solution:**
 - ❖ Remove subsea sensors
 - ❖ Allowing monitoring of all units of a commercial farm
 - ❖ Adaptable with respect to change of configuration/critical areas
- **Reduction of OPEX costs:**
 - ❖ Condition based predictive maintenance
 - ❖ Avoid dramatic failure under unexpected event by fast intervention

PROTOTYPE / PILOT FARMS



COMMERCIAL FARMS

Direct Monitoring on few units
SHM on all units



AFFIDA PROJECT – Structural Health Monitoring (SHM) for FOWT



Case Study for PGL Pilot Farm



- 1MEuros Funding :



- 2 years Research Project

- Project Partners :



- Case Study on **Provence Grand Large (PGL)**

- Software to be plugged in **PGL SCADA**

- Real Time / Automatic Monitoring of:

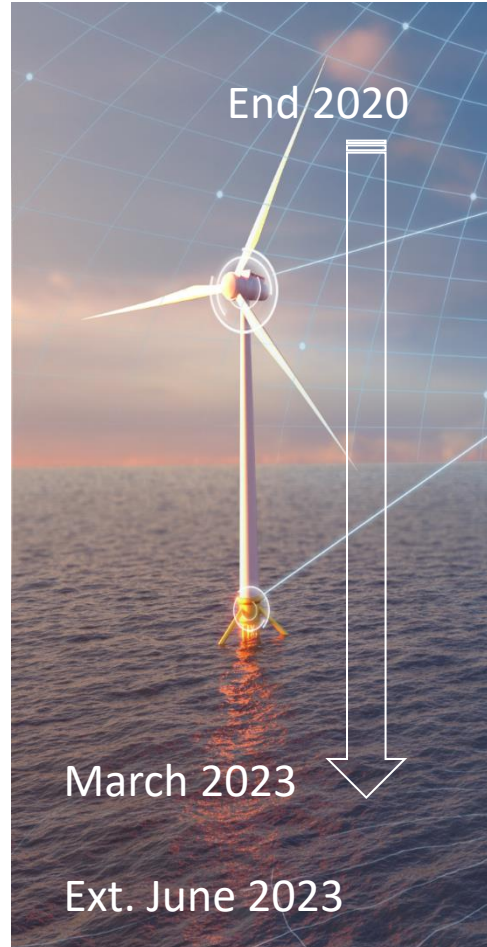
- Mooring lines Fatigue life
- Floating platform Fatigue life
- Power cable Fatigue life



AFFIDA PROJECT – Project Timeline



Case Study for PGL Pilot Farm



- Adaptation of the methodology to a FLOATING wind turbine
 - Iterations with EDF-RE → PGL project specificities: input data collection...
 - Set-up the model and Generate a large number of numerical data on a global model (HPC)
-
- Prognosis phase.
 - Test phase
- } Implementation on PGL hosting system

AFFIDA PROJECT – DTA m tool



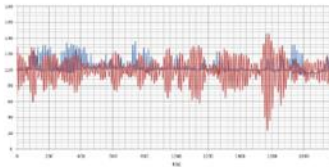
Case Study for PGL Pilot Farm



WIND FARM on SITE



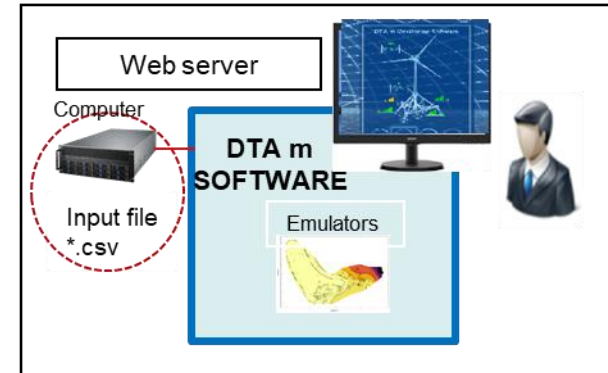
Nacelle's motions



Floater's motions



OPERATION CENTER



Any Questions?

**Thanks for your
attention!**

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